Topography-Guided LASIK Enhancements

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Refractive surgery patients may experience irregular astigmatism induced by small and/or decentered ablations. These types of refractive errors are difficult to correct with standard treatments because of their irregular nature and are more suited to correction using customized ablations.

Our experience suggests that topography-guided treatments may be an effective way to treat irregular astigmatism, small optical zones, and decentered ablations in symptomatic post-LASIK patients (Figure 1). We have managed these complications with the wavefront-guided approach with relative success. Topography-guided ablation is a form of customized ablation that uses current topography instead of a wavefront map as the basis for the treatment.1

This article summarizes our early clinical experience in the enhancement of symptomatic, previously performed LASIK surgery by topography-guided retreatments with the Allegretto Wave system (Wavelight Laser Technologie AG, Erlangen, Germany).

METHODOLOGY

Study Design

Our study was a retrospective consecutive enrollment case series of 17 eyes of 17 patients who underwent topography-guided enhancement with the Allegretto Wave platform following previous LASIK surgery for myopia. Dr. Kanellopoulos performed all surgeries in our refractive surgery center in Athens, Greece.

Enrollment

The study cohort included patients who had undergone LASIK surgery and were dissatisfied with their quality of vision. All eyes had a refractive error within ±1.50D (spherical equivalent) from residual myopia, hyperopia, or mixed astigmatism, with sufficient corneal tissue to leave a stromal bed of at least 250µm and no less than 400µm total after the planned retreatment. Predicted stromal bed depth and corneal thickness were based on preoperative records and on pre-enhancement pachymetry readings (Figure 2).

An additional criterion for study inclusion was our ability to obtain highly reproducible topographic maps to serve as the basis for the treatment.

Eyes were stratified into four treatment groups: (1) small optical zone (smaller than 0.5mm when compared to scotopic pupil size); (2) decentered ablation (optical zone eccentric more than 0.5mm than mesopic pupil outline); (3) irregular astigmatism (a difference of more than 0.75D in astigmatism between two corneal hemimeridians); or (4) night vision problems.

Preoperative Assessment

Preoperative evaluations of patients included refraction (manifest, cycloplegic, and wavefront), UCVA, BSCVA, the measurement of scotopic pupil size (Colvard Pupillometer; OAIS Medical, Inc., Glendora, CA), and topography with the Orbscan II topographer (Bausch & Lomb, Rochester, NY). We measured each patient’s contrast sensitivity before and after surgery under mesopic conditions using low contrast charts, and we measured patients’ glare preoperatively.

Figure 1. Preoperatively, a patient presented with a small effective optical zone of 4.0mm post-LASIK and significant night vision problems (map 1). The patient’s optical zone was effectively enlarged to 5.4mm (map 2).
by means of the CSV-1000 (Vectorvision, Arcanum, OH). Any intraoperative complications were noted in the patient's chart.

Corneal asphericity (Q value) was computed from the corneal topographies and was based on the central 20º area.

**Topography**

We obtained topographies with the Wavelight Topolyzer (Wavelight Laser Technologie AG), which integrates with the Wavelight excimer laser via the T-CAT software.

High-quality topographic maps require good alignment of the visual axis with the topography machine and adequate sampling of the corneal surface. Patients were therefore instructed to maintain fixation on the Topolyzer’s fixation target. Eyes with topographies that sampled less than 75% of the corneal surface were excluded, as were eyes in which reproducible maps could not be obtained. Treatments were calculated from the average of eight individual, high-quality topographic maps per eye.

In terms of the criteria that defined reproducible maps, we used an examiner’s assessment of the qualitative and quantitative distribution of astigmatism on the topographic maps. The software calculated the specificity of each topography test, according to the quality of data received (the refractivity of the corneal and surface data missing); only examinations with more than 95% accuracy were included by the software.

The examiner also compares the amount and axes of astigmatism. We generally forgave deviations in axis of up to 0.25D and up to 4º between topographies that are selected, and we usually only chose maps of 99% and above specificity (we required eight maps ideally but would proceed with a minimum of five). The aforementioned is our general thought process in ensuring topographic reliability. We have had to map some corneas more than 100 times in order to obtain reproducible data.

**Flaps and Ablations**

All cases involved lifting the original LASIK flap. No recuts were performed. After applying topical anesthesia (Alcaine; Alcon Laboratories Inc., Fort Worth, TX), Dr. Kanellopoulos traced the flap’s edge from the previous surgery under the excimer laser’s built-in slit lamp with a Sinskey hook (Katena Products, Inc., Denville, NJ), and he extended the separation between the flap and the corneal bed with the same instrument. We obtained ultrasonic pachymetry measurements (Echoscan; Nidek Inc., Fremont, CA) preoperatively and following the lifting of the flap, and we used these data to confirm the thickness of the residual bed before the new ablation was performed. The ablations were made with the Allegretto Wave excimer laser system, which uses a flying spot laser with a 0.95-mm diameter. After the ablation, Dr. Kanellopoulos floated the flap back into place and verified proper flap alignment according to the preoperative markings.

**Postoperative Evaluation**

At scheduled follow-up intervals, slit-lamp examinations were performed to assess the LASIK flap for complications. We repeated BCVA measurements and refractions, took contrast sensitivity measurements, and analyzed serial corneal topographic maps for any signs of corneal ectasia.

Patients were evaluated 1 hour, 1 day, 1 week, 1 month, 3 months, and 6 months postoperatively. All patients were available for follow-up until the 6-month postoperative enhancement. Mean follow-up time was 6.5 ±1.12 months (range, 5 to 13 months).

Patients were also asked to rank their subjective impression of their visual function on a scale of -1 to 3. Zero represented no improvement, -1 represented worsening, and 1 to 3 represented varying levels of improvement.

**Results**

At 6 months, all patients achieved an improvement in their mean UCVA, BCVA, corneal asphericity, and contrast sensitivity scores. Mean UCVA improved from 20/31 (±0.21 SD) to 20/24 (±0.15 SD). Mean BSCVA improved from 20/25 (±0.14 SD) to 20/18 (±0.12 SD). Likewise, the average refractive error improved from sphere of -0.50D (range, -1.50 to +1.25D) to -0.14D (range, -1.50 to +0.59D), and mean cylinder amounts were reduced from -1.15D (range, 0 to -2.00D) preoperatively to -0.56D (range, 0 to 1.00D) postoperatively (Tables 1 and 2).

![Figure 2. A patient presented with a relatively small (4.6mm) and irregular optical zone post-LASIK for myopia (map 1). After enhancement surgery, the topographic map illustrated an enlargement to 5.4mm and a relative smoothing of the optical zone (map 2).](image-url)
Corneal asphericity (Q-value) improved from +0.7 to +0.1. Mean contrast sensitivity scores at 12 cycles/degree improved by 70% from a mean of 3.56 to 6.05 and at 6 cycles/degree from a mean of 4.21 to 5.23. Similarly, there was a marked improvement in symptoms of 0 to +2 based on the subjective rating scale. The mean patient satisfaction score was 0.88.

**Discussion**

**Vision Enhancement**

We noted an improvement in the overall quality of vision in most of the patients. Preoperative refractive sphere (-0.84 ±1.37 SD) improved to -0.61 ±0.81D SD (not significant, P=0.52), and preoperative cylinder (-0.55 ±0.78 SD) changed to ±0.58D (not significant, P=0.92). UCVA increased from 20/29 ±0.22 SD to 20/21 ±0.21 SD (not significant, P=0.11). BSCVA improved from 20/22 ±0.15 SD to 20/21 ±0.14 SD (not significant, P=0.23). The Q-value was enhanced to 1.07 ±0.89 SD from 1.26 ±0.79 SD. Contrast sensitivity scores improved by 70%. Corneal irregularity showed a statistically significant improvement from 52 ±13 SD to 46 ±13 SD (P=0.04). No patient lost BSCVA.

One limitation of this study was the lack of a control group. Designing a controlled study to compare different treatments for complications is difficult, because no two irregular ocular surfaces are alike.

**Corneal Surface and Curvature**

The corneal surface is the principal refracting element of the eye; the air-to-tear-film interface is responsible for the majority of refracted light entering the eye. Changes to the corneal surface dramatically alter the refraction of the eye, and, correspondingly, any irregularity in the corneal surface dramatically affects the quality of vision.

Eyes with decentered and/or small optical zone ablations may experience a loss of BSCVA, decreased contrast sensitivity, and visual disturbances such as haloes and starbursts. These symptoms can be especially annoying under mesopic conditions when the pupil dilates and exposes more of the irregular cornea.

Prior reports describe the use of customized ablations, including topography- and aberrometer-guided treatments of eyes with irregular surfaces after LASIK. Most aberrometer-guided treatments attempt to ablate the cornea with a reciprocal shape to negate optical aberrations. Topography-guided ablations attempt to contour the corneal surface to match an ideal curve. Thus, aberrometer- and topography-guided treatments differ significantly in their approach to treating postoperative aberrations.

Topography-guided treatments may have advantages over wavefront-guided treatments for complicated eyes. For example, topography can often image eyes with highly irregular corneas that are beyond the imaging limits of aberrometers. Topography-guided treatments can also be used in cases that have media opacities such as corneal scars, because its measurements are based solely on the surface. In addition, it is possible to factor a Q-value into topography-guided treatments to preserve or re-establish the natural aspheric shape of the cornea.

A major disadvantage of topography-guided ablation is that the procedure ignores the rest of the refracting media because it concentrates mainly on the corneal contour. This disadvantage was probably the reason for some of the refractive surprises we encountered. For example, in order to widen the optical zone of previously myopic eyes, the treatment would require the laser to flatten tissue peripherally, and the ablation pattern would resemble that of a hyperopic treatment, thus causing some amount of myopic shift. Certain eyes may require a subsequent enhancement procedure to correct the remaining spherical refractive error. We have had some success in developing nomograms to improve the refractive correction in topography-guided treatments.

Two of our patients (11%) still had symptomatic complaints despite obvious topographic changes. Their complaints were attributed to irregularities in the ocular media other than those on the corneal surface.

**Similar Study, Similar Results**

A comparable series by Knorz and Jendritza evaluated topography-guided treatments using a different excimer laser platform on 29 eyes for indications such as postoperative surgical irregularities, trauma, and PRK and LASIK irregularities. Eleven of the patients had small and/or decentered ablations, similar to our patient population. Of this subgroup, 91% of patients had an improvement in UCVA. In the same group, mean visual acuity improved from 20/60 to 20/50, but the improvement in vision was not statistically significant. The problems encountered in that series included undercorrections and difficulty centering the treatment, as there was no direct link between the topography and the excimer laser centration. With the Wavelight system, however,
both the topographic image and excimer laser centration are centered on the pupil using an active tracker, and we did not encounter centration errors in this series. Nevertheless, as mentioned earlier, we also had unpredictable refractive outcomes.

In our series, topography-guided treatments were effective in correcting irregularities caused by the patients’ previous refractive surgeries, and they resulted in better visual function. Although we encountered some refractive changes in terms of refractive sphere that may require further standard enhancement, overall, this technique was successful but could benefit from confirmation with further studies of larger sample sizes and longer follow-up periods.

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